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UNITED STATES DISTRICT COURT

EASTERN DISTRICT OF CALIFORNIA

PACIFIC COAST FEDERATION OF FISHERMEN'S ASSOCIATIONS, *et al.*, Plaintiffs, v. GINA RAIMONDO, *et al.*, Defendants	Case No. 1:20-cv-00431-JLT-EPG Case No. 1:20-cv-00426-JLT-EPG **DECLARATION OF BRADLEY CAVALLO IN SUPPORT OF SACRAMENTO RIVER INTERVENORS' OBJECTION TO INTERIM OPERATIONS PLAN EXTENSION**
THE CALIFORNIA NATURAL RESOURCES AGENCY, *et al.*, Plaintiffs, v. GINA RAIMONDO, *et al.*, Defendants.	Date: TBD Time: TBD Dept. 5 Judge: Jennifer L. Thurston

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I, Bradley Cavallo, declare that the following facts are true and correct.

I. Introduction

1. I am a fisheries biologist with more than 21 years of specialized experience in the study of Central Valley Chinook salmon. I am a Principal at Cramer Fish Sciences (CFS) where I have been employed since 2006. CFS was founded in 1987. We specialize in assessing the productivity and limiting factors of fish populations and their habitats and developing and implementing restoration, research, and monitoring plans. We have a staff of more than 50 fisheries biologists, ecologists, fluvial geomorphologists, geneticists, biometricians, and biotechnicians at six locations throughout the West Coast. Since its inception, CFS has provided fisheries scientific consulting services for a wide variety of federal, state, local, and non-governmental entities. Further information regarding my qualifications to render opinions contained in this declaration are set forth in my professional resume, attached hereto as Exhibit A and incorporated herein by this reference.

2. I have been retained as an expert to provide expert opinions and testimony on behalf of the Defendants-Intervenors, the Sacramento River Settlement Contractors (SRS Contractors) and the Tehama-Colusa Canal Authority (TCCA), collectively known as the "Sacramento River Intervenors" in the above-referenced actions. I have previously submitted an expert declaration in these proceedings in January 2022 (*PCFFA* ECF No. 333; *CNRA* ECF No. 240) (Jan. 2022 Decl.), which appended as exhibits thereto my June 8, 2020 Declaration in the *PCFFA v. Raimondo* case, and my expert report in *Natural Resources Defense Council v. Zinke*, Case No. 1:05-cv-1207 (E.D. Cal.).

3. Throughout my career (since 1999), I have studied salmonid populations of the Sacramento River basin and analyzed the effects of water project operations. I have extensive knowledge of rivers regulated by dams and the ecology of Chinook salmon and steelhead. Much of my work has focused on quantitative analyses, including life cycle modeling and simulation modeling, to evaluate the influence of river flows, water temperatures and other factors on the survival of Chinook salmon. I have worked on numerous fisheries projects throughout California's Central Valley. My work has included multiple aspects of evaluating the status and trends of fish

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populations and adverse environmental impacts affecting anadromous fish populations. As a specific example, I was hired by the California Department of Water Resources (DWR) to be the lead scientist for research programs assessing environmental impacts of the California State Water Project's operations on salmon and steelhead in the Feather River, Sacramento River, and the Sacramento-San Joaquin Delta. In other consulting projects, I was hired by DWR to develop a winter-run Chinook salmon life cycle model for evaluating proposed water project operations. I was also hired by the Metropolitan Water District of Southern California and the State Water Contractors to develop a simulation model for how water management in the Sacramento-San Joaquin Delta may influence migration and survival of juvenile Chinook salmon. I was hired by the United States Bureau of Reclamation (Reclamation) to develop an Adaptive Management Plan for winter-run Chinook salmon in relation to the Coleman National Fish Hatchery and the Battle Creek restoration effort.

4. During water years 2020 through 2022, I was personally involved in numerous meetings, conference calls, and discussions with SRS Contractors, Reclamation, DWR, the National Marine Fisheries Service (NMFS), the California Department of Fish and Wildlife (CDFW), and others to review and discuss the analysis and interpretation of fisheries monitoring data. I regularly and actively participate in interagency science information sharing forums including the Sacramento River Science Partnership and the winter-run Chinook Project Work Team.

5. I have reviewed and evaluated the requested extension of the Interim Operations Plan for the Central Valley Project (2023 IOP Extension) proposed by Federal Defendants and State Plaintiffs. The following are my opinions and responses to certain aspects of that request associated with Shasta Operations and winter-run Chinook salmon.

II. Summary of Opinions

- My January 2022 Declaration explained that the then proposed 2022 Interim Operations Plan (2022 IOP) was "predicated on the reliability and accuracy of the Martin model—both for defining a critical temperature for egg incubation and for quantifying temperature dependent mortality . . . . The Martin model is clearly not

appropriate or reliable for determining how to manage Sacramento River water temperatures." Jan. 2022 Decl. at 4:18-22.[1]

- Despite maintaining water temperatures purported to achieve a 17% temperature-dependent mortality rate, production of juvenile winter-run Chinook in 2022 has been poor. If the present trend continues, 2022 will have among the lowest egg-to-fry survival rates ever observed on the Sacramento River.
- Biological outcomes observed to date for 2022 strongly suggest the singular focus on managing water temperatures during egg incubation is misplaced, as is the reliance on the Martin model to precisely predict and manage temperature-dependent mortality during egg incubation. The Martin model is clearly not appropriate or reliable for determining how to manage Sacramento River water temperatures.
- Thiamine deficiency at best provides an incomplete explanation for poor production of juvenile winter-run Chinook resulting from implementation of the 2022 IOP.
- The focus on managing for coldest-possible water temperatures during egg incubation while inadequately considering how flows and temperatures might affect production of juvenile winter-run Chinook was a major flaw in the 2022 IOP.
- The 2020 IOP should not be extended as proposed through 2023 and Shasta operations should be performed in accordance with the 2019 NMFS BiOp in 2023. Alternative flow and temperature management strategies, augmented collection of adult winter-run Chinook, thiamine-treatment for in-river spawners, and studies to better quantify egg and fry survival should be included as elements of any revised IOP for 2023.

[1] ECF pinpoint citations are to ECF pagination unless specified otherwise.

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III. 2022 Status of Winter-run Chinook in the Sacramento River

6. My January 2022 Declaration provides a summary of winter-run Chinook spawning abundance, estimated fry production, and estimated egg-to-fry survival for 1996-2021. Jan. 2022 Decl. at 4-24. Exhibit B thereto at explains that Sacramento River winter-run are unique in that they are the only Chinook salmon run spawning in summer months. *Id.* at 61-62. Adults (Figure A) enter freshwater in winter and spring and hold until they initiate spawning in late spring and summer. Eggs (Figure A) incubate in the gravel and emerge in late summer and early fall. Some fry initiate migration out of the spawning grounds soon after hatch and disperse to downstream rearing habitats while others will rear near the spawning grounds. Juveniles (ranging from fry to pre-smolt sized fish) enter the Sacramento-San Joaquin Delta in the late fall and winter and leave the Delta for the Pacific Ocean primarily in March and April. Fish spend several years in the ocean before returning to freshwater when they are 2-4 years old. A large majority of fish return at age 3.

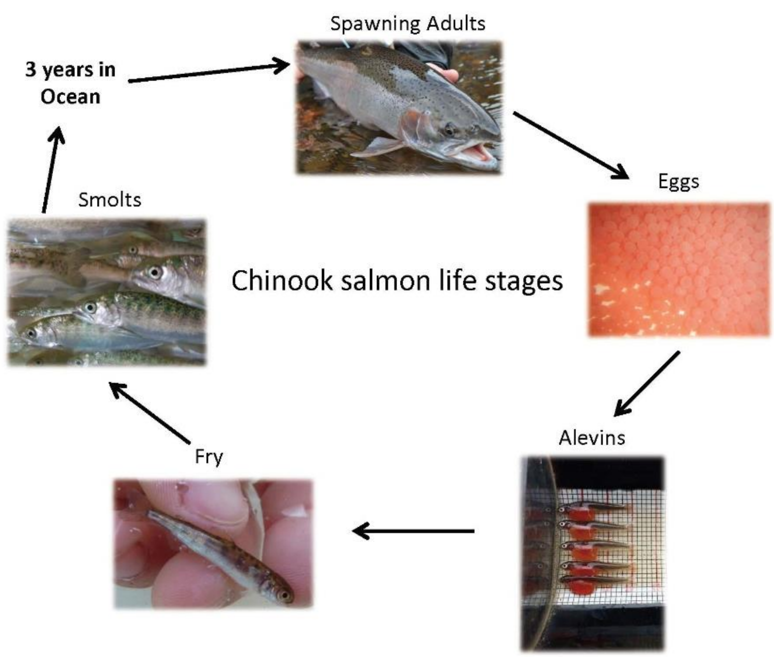

Figure A. Key life stages for Chinook salmon. Fry through smolt life stages are collectively referred to as juveniles.

The locations for each of adult spawning, egg incubation, and juvenile life stages in the upper Sacramento River are shown in Figure 2.

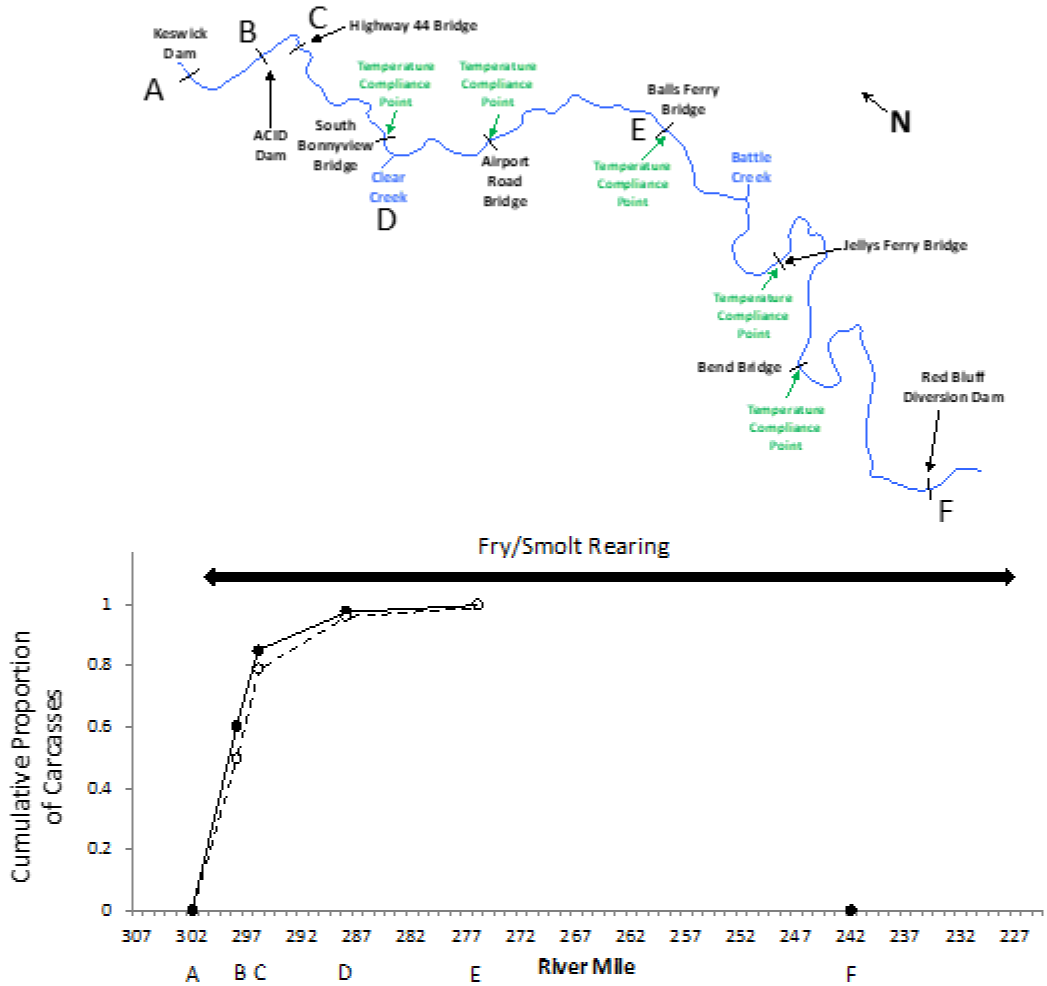

Figure B. The Sacramento River from Keswick to Red Bluff Diversion Dam (upper panel) where upper case letters indicate specific locations referred to in the lower panel. The lower panel depicts the cumulative distribution of winter run Chinook spawning (as indicated by carcass surveys) in 2014 (solid line) and 2015 (dashed line), and the range of juvenile rearing (horizontal solid black arrow). In 2022, winter run spawning continued to be heavily skewed to the uppermost five miles of the Sacramento River (between Keswick [A] and Hwy 44 Bridge [C]).

7. In 2022, winter-run Chinook spawning in the Sacramento River occurred between May and August, with a peak in July. Annual abundance estimates for in-river spawning winter-run Chinook salmon are provided by a carcass survey conducted by CDFW. An abundance estimate for the 2022 winter-run Chinook spawning population has not yet been released. However, CDFW's carcass survey collected 1,656 winter-run salmon carcasses from the spawning grounds (CDFW 2022). Between 2003-2021, carcass survey recoveries have averaged 47% (95%

confidence interval 41.5%-53.3%) of the final spawning abundance estimate. Assuming this year's carcass survey was typical, abundance of in-river spawning winter-run Chinook in 2022 will likely fall between 3,107 and 3,990 individuals, with a mean of 3,523 (see Table 1).

							Without Thiamine-dependent survival		With Thiamine-dependent survival	
	Percent of carcass counts to final in-river population (2003-2021 average)	Winter-run in-river adult spawning population	Females (assume 50% of spawners)	Eggs (assume 5,000 per female)	Juvenile Winter-run at Red Bluff Diversion Dam (SacPAS 10/26/2022)	Egg-to-fry survival	Martin model predicted juvenile winter-run at Red Bluff Diversion Dam	Martin model predicted egg-to-fry survival	Martin model predicted juvenile winter-run at Red Bluff Diversion Dam	Martin model predicted egg-to-fry survival
Lower Range	42%	3,990	1,995	9,975,904	126,398	1.4%	2,992,771	30%	1,639,440	16%
Mean	47%	3,523	1,762	8,808,511	165,000	1.9%	2,642,553	30%	1,447,591	16%
Upper Range	53%	3,107	1,553	7,767,355	250,216	2.8%	2,330,206	30%	1,276,487	16%

Table 1. Summary of information available for 2022 winter-run Chinook salmon adults and juvenile production. Adult (carcass) data from CDFW (2022). Juvenile winter-run abundance estimates from data shown in Figure 1. See text for description of observed egg-to-fry survival at RBDD, and estimates produced by the Martin model with and without thiamine deficient survival.

8. According to CDFW's carcass survey data (CDFW 2022), more than 1,000 carcasses were assessed for being hatchery origin (with an adipose fin clip) or natural origin (without an adipose fin clip). This data indicates approximately 90% of winter-run Chinook salmon (i.e., 2,796 to 3,591 individuals) on the spawning grounds were of natural origin in 2022.

9. The United States Fish and Wildlife Service (USFWS) operates Livingston Stone National Fish Hatchery (LSNFH), a conservation hatchery program supported in the NMFS recovery plan (NMFS 2014) and permitted under the Federal Endangered Species Act (ESA) (NMFS 2017). Adult winter-run Chinook salmon are collected from a trap located at Keswick Dam in order to supply broodstock for LSNFH. As a condition of its ESA permit, LSNFH is required to rely exclusively on naturally produced winter-run Chinook for its broodstock. Using hatchery returns as broodstock contributes to domestication selection—the loss of traits that allows salmon to survive and reproduce successfully in the natural environment—and undermines the conservation value of the hatchery program.

10. Collections of adult Chinook salmon at the Keswick Dam trap were expanded in 2022 to allow for increased production of juvenile winter-run Chinook salmon at LSNFH and for

experimental reintroductions into the McCloud River and Battle Creek. The allocation of adult winter-run Chinook collected at the Keswick Dam trap in 2022 for these different purposes has not yet been reported. However, available data indicates approximately 58% of winter-run collected were hatchery-origin returns. Therefore, it is unlikely LSNFH was able to meet the requirement of using 100% natural origin winter-run Chinook for hatchery broodstock in 2022. Attaining sufficient numbers of natural origin winter-run Chinook for use as broodstock has been a problem for LSNFH since 2019, despite natural origin fish being relatively abundant in the Sacramento River.

11. Juvenile winter-run Chinook salmon produced by in-river spawning adults are estimated by traps operated at Red Bluff Diversion Dam (RBDD). Further background on the methodology, assumptions and uncertainties associated with juvenile winter-run production estimates are provided in my January 2022 Declaration. *PCFFA* ECF No. 333 at 12-20; *CNRA* ECF No. 240 at 12-20. Winter-run fry (the youngest and smallest life stage) produced by adults spawning in 2022 began to arrive at RBDD in early July and production estimates have been provided by USFWS for every two-week interval through October 21, 2022 (at the time this declaration was drafted). Based on observations from prior years (2007-2021), 74% (range 49% to 97%) of juvenile winter-run Chinook salmon are expected to have emigrated past RBDD by October 21st (see Figure 1).

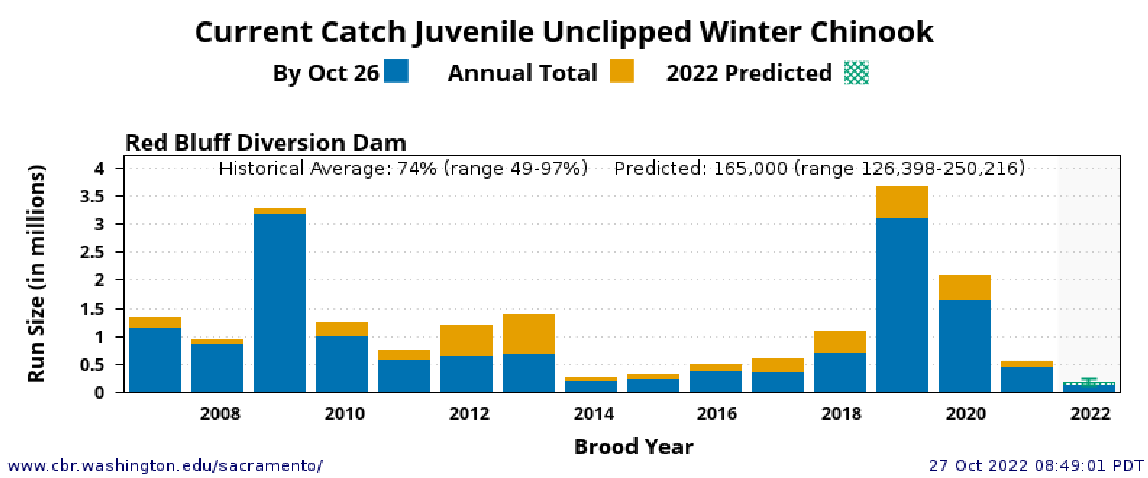

Figure 1. Juvenile winter-run Chinook abundance estimates, 2007-2022. Not all juvenile winter-run Chinook produced by spawning in 2022 have migrating past the Red Bluff Diversion Dam monitoring site. However, trends suggest juvenile winter-run Chinook production will be poor despite WY 2022 operations. Source: https://www.cbr.washington.edu/sacramento/data/currcatch.html.

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While it is possible that emigration of winter-run fry is unusually delayed in 2022, a forecast based on catch to-date suggests poor juvenile production, with a mean predicted estimate 165,000 fish (range 126,398 to 250,216). If the current trend continues, 2022 will have the lowest level of winter-run fry production ever observed on the Sacramento River. Even if the high range abundance forecast based on RBDD catch is doubled (from 250,216 to 500,432 fish)—for example by large pulses of late arriving juveniles—fry production in 2022 will still be comparable to poor production observed in 2014 and 2015 drought years.

12. Another method for estimating the number of fry produced (and potentially arriving at RBDD) is to multiply the estimated number of female, in-river spawners by the average number of eggs per female spawner (fecundity). This simple calculation provides the denominator for the USFWS's estimate of Egg-to-Fry (ETF) survival:

$$ETF\ survival = \frac{JPI}{\text{Females spawning in river} * \text{average female fecundity}}$$

13. In the formula above, JPI is the fry-equivalent Juvenile Production Index estimated by juvenile outmigrant trapping at the RBDD. Spawning abundance data described previously combined with the assumption that half of all spawners were female and that fecundity was 5,000 eggs per female (the average of value observed over the last five years) suggests ETF survival will likely be very low in 2022 (Table 1); between 1% and 3%.

14. The Martin model uses estimates of ETF survival calculated by this same method to make predictions of ETF survival based on the number of female spawners and water temperatures experienced during egg incubation. Based on water temperatures experienced by incubating winter-run Chinook in 2022, the Martin model predicts 17% temperature-related mortality (NMFS 2022a) (Oct. 13 2022, NOAA Fisheries Southwest Fisheries Science Center [SWFSC] presentation). The Martin model assumes all sources of mortality not attributable to egg incubation temperature effects are fixed as "background survival" at a rate of ~36% (Figure 2).

Going from TDM to ETF:

$$ETF = (S_o \times DD) \times (1 - TDM) \times TDS$$

- S_o = *Background survival w/out temperature and density dependence effects, ~36%*
- DD = *Background survival w/ density dependence*
- TDM = *Temperature-dependent egg mortality (TDM)*
- TDS = *Thiamine-dependent survival (TDS)*

Figure 2. Slide from NMFS (2022a) showing how background survival, density-dependence effects, and temperature-dependent mortality are used to estimate egg-to-fry (ETF) survival. Thiamine-dependent survival (TDS) is also shown in this equation. However, TDS was not part of the original Martin model (Martin et al. 2016), and though it has been studied by NMFS-SWFSC since 2020, detailed methods and results from those studies have not been shared with the broader scientific community. Therefore, it is not clear what estimates of thiamine-deficient survival might be incorporated into the Martin model.

Background survival does not change from year-to-year, however when a spawning abundance threshold is exceeded, an additional survival penalty is imposed on background survival (Figure 2). Spawner abundance almost certainly did not exceed the density-dependence threshold in 2022, therefore the Martin model prediction of ETF survival should be:

$$Martin\ ETF = S_o * (1 - \mathrm{TDM})$$

15. In the above formula, S_o is background survival (~36%) and TDM is temperature dependent egg mortality. Since TDM was estimated at 17% (NMFS 2022a), the Martin model's predicted ETF survival rate was ~30%. Applying this ETF survival rate to the number of eggs assumed to have been deposited by females indicates between 2.3 and 2.9 million fry should arrive at RBDD in 2022 (Table 1).

16. Beginning in 2020, thiamine deficiency has been studied as an additional source of mortality significantly affecting survival of winter-run Chinook eggs and fry. Detailed methods and results from these studies have not been shared with the broader scientific community. Further discussion of thiamine deficiency is provided below in paragraph 29.

17. Central Valley Chinook salmon are subjected to a uniquely intensive mixed-stock[2] commercial and recreational ocean fishery. Ocean harvest impact rates for Central Valley Chinook salmon are greater than those typically experienced by salmon originating from the Klamath River system and for Chinook stocks originating north of Oregon (Figure 3). Ocean harvest of Central Valley Chinook was substantially curtailed in 2008-2010 due to the collapse of that stock (Lindley et al. 2009), but the ocean harvest impact rate for Sacramento fall-run Chinook has rebounded to an annual average of 58% (range 42-68%) since 2011 (PFMC 2022), and so has returned to levels that occurred before the 2008-2010 stock collapse (Figure 3).

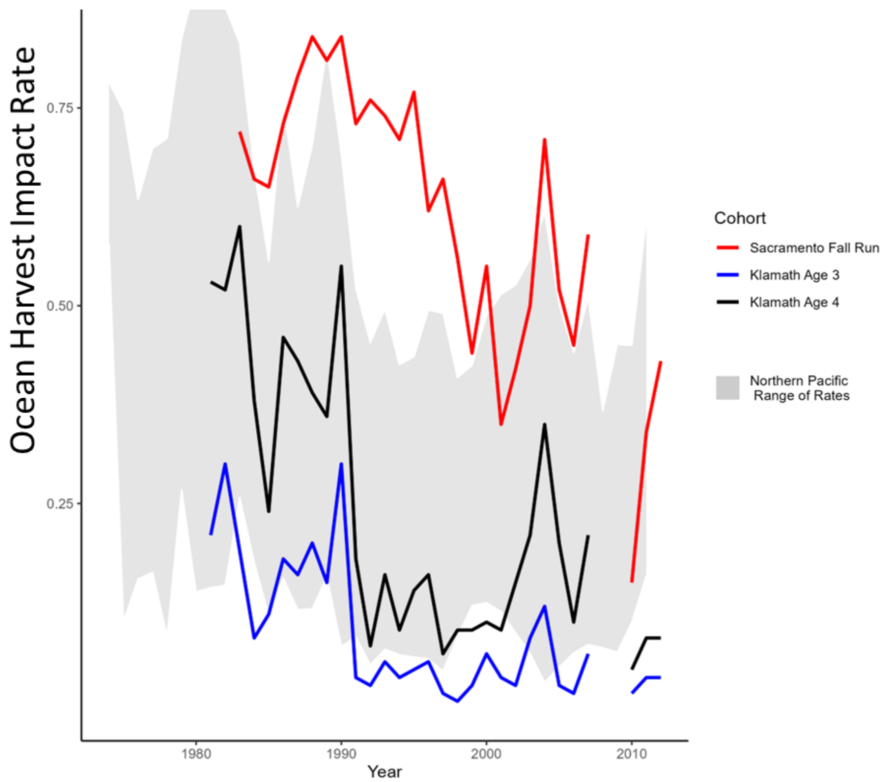

Figure 3. Ocean harvest impact rates for Sacramento basin fall-run Chinook salmon (red line), Klamath basin fall-run Chinook age 3 (blue line) and age 4 (black line). Grey shaded area depicts the range of ocean harvest impact experienced by Chinook salmon stocks originating from Oregon, Washington, British Columbia, and Alaska. California Chinook harvest data from PFMC (2022). Northern Pacific stocks include Alaska spring-run, Elk River, George Adams fall-run, Nisqually fall-run, Nooksack spring-run, Robertson Creek fall-run, Skagit spring-run, Skykomish fall-run, South Puget Sound fall-run, Salmon River, Stillaguamish fall-run, and Willamette spring-run (PSC 2019).

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[2] In mixed-stock fishery for Chinook salmon, different runs (e.g., fall-run, spring-run, winter-run), populations originating from different rivers systems, populations produced by hatcheries vs. natural origin populations, and fish of different ages are intermingled and all are exposed to harvest. For Chinook salmon in the Columbia River basin, most harvest does not occur in a mixed-stock ocean fishery. Rather harvest occurs as fish return to freshwater for spawning, which allows specific stocks to be targeted and does not disproportionally impact older age classes.

18. Because it is a mixed-stock ocean fishery, harvest directed at Sacramento fall-run Chinook impacts winter-run Chinook and other ESA listed stocks. Winter-run Chinook salmon are large enough to be impacted by ocean harvest at age 2 (Sattherthwaite et al. 2017). Winter-run maturing at age 3 return to freshwater in winter, thereby avoiding any additional exposure to the ocean fishery which does not open until April or later. Minimum size limits and season-area closures are used to keep ocean harvest impacts to age 2 winter-run Chinook—fish that will mature at age 3—below 20%. This 20% maximum harvest impact rate for winter-run that will mature at age 3 is stipulated in the biological opinion for ocean salmon fishery impacts (NMFS 2010). Prior to the implementation of this new biological opinion—for the years data is available, 2000 to 2011—estimated harvest impact rates to age 3 winter-run Chinook were as high as 28% (PFMC 2022). For 2012 to 2020, age 3 harvest impacts have ranged between 10.0% and 18.8%, averaging 14% (PFMC 2022). Ocean harvest impact to age 3 winter-run in 2021 and 2022 have not yet been provided by the Pacific Fishery Management Council, and so impacts in the most recent years are not known.

19. While the 2010 biological opinion (NMFS 2010) improved ocean harvest protection for winter-run at age 3, it did not address impacts occurring for fish maturing at age 4. Winter-run Chinook salmon maturing at age 4 are exposed to a full-season of ocean harvest during which they are not protected by either minimum size limits or seasonal-area closures. Analyses have shown that ocean harvest impacts to age 4 winter-run Chinook can be 55% to 70% (O'Farrell et al. 2012)—comparable to ocean harvest impacts experienced by Sacramento fall-run Chinook.

20. The ESA consultation for ocean harvest impacts to winter-run Chinook (NMFS 2010) functionally assumes all winter-run Chinook mature at age-3, and does not consider or regulate ocean harvest impacts to fish maturing at age 4. Hallock and Fisher (1985) reported that 8% of adult winter-run Chinook matured at age 4, and more recent aging of natural-origin winter-run Chinook (presented to the January 14, 2022 winter-run Project Work Team) suggests the proportion of age 4 adults averaged ~10% between 2005 and 2018. Variation in age-at-maturity is important for the viability of all runs of Central Valley Chinook salmon because it buffers populations from short-term environmental changes in freshwater or from catastrophic events; a

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feature of population diversity commonly referred to as the "portfolio effect." It is important to recognize that age of maturity is a strongly heritable trait among salmonids, and that larger, older fish typically produce more juvenile offspring (Ohlberger et al. 2020; Oke et al. 2020). While intensive ocean harvest pressure is reducing the abundance of age 4 (and older) winter-run Chinook, it is also selecting against fish maturing at older ages. This loss of diversity in age of maturity among winter-run Chinook salmon detracts from the viability of the ESU, particularly during multi-year droughts such as the one we are currently experiencing.

IV. 2022 IOP operations for water temperature management

21. The Declaration of Cathy Marcinkevage filed in support of the proposed IOP Extension (*CNRA* ECF No. 286-4 at ¶ 11; *PCFFA* ECF No. 406-4 at ¶ 11) describes the prioritized structure for making operational and species management decisions under the 2022 IOP. Though it differed from the original 2022 IOP in some ways—targeting water temperature management at the Hwy 44 Bridge (river mile 296) rather than at the Clear Creek gage (river mile 292)—water temperatures and estimated TDM improved over the season relative to earlier projections provided by the SWFSC (NMFS 2022a). For example, the distribution of redds observed between 2016-2021 and the May temperature modeling results indicated temperature-dependent mortality of 42% was expected for the 2022 cohort of winter-run Chinook. However, winter-run redds were distributed further upstream and water temperatures at the Hwy 44 bridge remained below 55°F until September 21st and did not reach 56°F until October 14th. Based upon the spatial and temporal distribution of female salmon carcasses, CDFW projects the weekly proportion of winter-run eggs expected to have hatched and emerged as fry from spawning gravels (Table 2). These data indicate 75% to 88% of fry emerged had emerged by October 1st, and 94% to 97% had emerged by October 15th. The latest predictions of water temperature effects from the Martin model also suggest favorable incubation conditions, with a TDM estimate of just 17% (NMFS 2022a).

Date	Percentage of winter-run eggs expected to have emerged
Sepetember 1st	13 to 22%
September 15th	30 to 48%
October 1st	75 to 88%
October 15th	94% to 97%

Table 2. Data from CDFW (2022) depicting the predicted proportion of winter-run eggs hatched and emerged by biweekly intervals in September and November.

22. According to the Marcinkevage Declaration, 2022 Sacramento River water temperatures "outperformed" the objectives of the final 2022 Temperature Management Plan. *CNRA* ECF No. 286-4 at ¶ 16; *PCFFA* ECF No. 406-4 at ¶ 16. At paragraph 13, the Marcinkevage Declaration explains this was accomplished by capping Keswick Dam to "average monthly releases between May and September at 4,000-4,500 cubic feet per second to protect winter-run Chinook salmon and build storage in Shasta Reservoir . . . . Both the release schedule and SRSC diversions ***were dramatically lower than any past year, resulting in extremely low summertime flows*** downstream of Keswick Dam that have not occurred since the construction of the Central Valley Project." (Emphasis added.)

23. An extension of the 2022 IOP through December 2023—with only minor modifications—is requested by the federal and state parties on the basis of the IOP's ostensible effectiveness in providing biological protections. Marcinkevage Decl., *CNRA* ECF No. 286-4 at ¶ 17; *PCFFA* ECF No. 406-4 at ¶ 17. However, very little information on the 2022 biological outcomes for winter-run Chinook salmon was available at the time the proposed 2023 IOP Extension request was filed. Data available through October 21st indicates winter-run fry production was poor in 2022. Biological outcomes observed to-date for 2022 strongly suggest the singular focus on managing water temperatures during egg incubation to 53.5°F is misplaced, as is the reliance on the Martin model to precisely predict and manage temperature-dependent mortality during egg incubation. As detailed in my previous declarations, available field data (female

spawners, fry-equivalent production at RBDD) are not suitable for reliably estimating temperature dependent egg mortality. Briefly, the correlation between egg incubation water temperatures and fry production is driven primarily by an inappropriate reliance on observations from the 2014 and 2015 drought years. The Martin model assumes all ETF mortality that occurred in 2014-2015 resulted from water temperatures experienced by incubating eggs. Results for 2022 affirm opinions from my prior declarations and demonstrate this assumption is incorrect. Drought year conditions (low flows and warmer temperatures) can exert a strong influence on winter-run fry production. If this were not the case, fry production in 2022 would have been as high as the Martin model predicted (see Table 1).

V. The 2022 IOP called for colder water than would have been required under the 2019 NMFS Biological Opinion, but results to date suggest winter-run Chinook did not benefit, and may have actually been harmed by the 2022 IOP operations

24. Among ongoing monitoring programs, the estimated abundance of juvenile winter-run Chinook salmon at RBDD provides the most appropriate basis for evaluating the effectiveness of biological protections provided by the 2022 IOP. Winter-run fry (the youngest and smallest life stage) produced by adults spawning in 2022 began to arrive at RBDD in early July and production estimates have been provided by USFWS for every two-week interval through October 21, 2022. Based on observations from prior years (2007-2021), 74% (range 49% to 97%) of juvenile winter-run Chinook salmon are expected to have emigrated past RBDD by October 21st (see Figure 1). While it is possible that emigration of winter-run fry is unusually delayed in 2022, a forecast based on catch to date suggests poor juvenile production, with a mean predicted estimate 165,000 fish (range 126,398 to 250,216). If the current trend continues, 2022 will have the lowest level of winter-run fry production ever observed on the Sacramento River. Even if the high range abundance forecast based on RBDD catch is doubled (from 250,216 to 500,432 fish)—for example by large pulses of late arriving juveniles—fry production in 2022 will be comparable to poor production observed in 2014 and 2015 drought years. It is important to note that adult spawning abundance in 2014 and 2015 was similar to likely spawning abundance in 2022 (3,107 to 3,990 fish). Since estimated temperature dependent mortality was very high in 2014 and 2015, and very low in 2022, winter-run Chinook juvenile production resulting from the 2022 IOP was

expected to be relatively strong. As described previously, applying the original Martin model to the likely number of female spawners in 2022 indicates between 2.3 and 2.9 million fry equivalents (Table 1) should have resulted from water temperatures provided by the 2022 IOP (Table 1).

25. Poor juvenile production observed to date strongly suggests that the 2022 IOP water temperature management actions failed to provide biological protections that were intended and expected to occur for winter-run Chinook salmon. The central premise of the 2022 IOP's Temperature Management Plan was that maintaining water temperatures as close as possible to 53.5°F during winter-run egg incubation is all that is required to assure successful production of juvenile winter-run Chinook salmon. This assumption has always been highly questionable, and the unique operations under the 2022 IOP (Marcinkevage Decl., *CNRA* ECF No. 286-4 at ¶ 13; *PCFFA* ECF No. 406-4 at ¶ 13), where water temperatures were kept cold by drastically reducing flows, has demonstrated factors other than water temperature strongly influence juvenile winter-run production.

26. According to 2022 winter-run aerial redd surveys (CDFW 2022), 98% of winter-run egg incubation took place in the limited river miles between Keswick Dam and the Hwy 44 Bridge in Redding. In contrast, after emerging from spawning gravels, winter-run Chinook fry must contend with habitat conditions over an additional 67 river miles before reaching RBDD. The 2022 IOP, and the Martin model upon which the 2022 Temperature Management Plan was based, assumes fry survival is unaffected by downstream habitat conditions.

27. River flows can influence the success and survival of winter-run Chinook salmon in a variety of ways.

- Adequate intergravel flows are critical to incubation success of Chinook salmon. Low river flows can reduce intergravel flow, contributing to dissolved oxygen limitation and reduced egg incubation success.
- River flows can influence the proportion of juveniles that leave the spawning areas as fry relative to smolts (Zeug et al. 2014; Vogel 2017), which in turn influences whether or not juveniles are able to find and utilize available rearing habitats.

- Lower flows can expose juveniles to elevated risk of predation during both rearing and downstream migration. This mechanism has been widely studied and affirmed across Central Valley rivers for both fry and larger juvenile Chinook salmon (e.g., Zeug et al. 2014; Michel et al. 2015; Perry et al. 2018).

However, the Martin model fails to account for these impacts and is therefore of limited utility in analyzing the historically low flow conditions experienced in the upper Sacramento River in 2022.

28. Results from the 2022 temperature management season affirm concerns that have been raised previously (e.g., Gore et al. 2018, Cavallo Declarations). The Martin model does not reliably predict temperature-dependent mortality and should not be used as the primary basis for consequential management decisions related to Sacramento River flows and water temperatures.

VI. Thiamine-deficiency alone cannot explain poor winter-run Chinook production in WY 2022

29. Beginning in 2020, thiamine-deficiency has been studied as an additional source of mortality affecting survival of winter-run Chinook eggs and fry. Detailed methods and results from these studies have not been made available. However, a July presentation (NMFS 2022b) included a graph depicting values for survival probability associated with thiamine deficiency in 2020, 2021 and 2022 (Figure 4).

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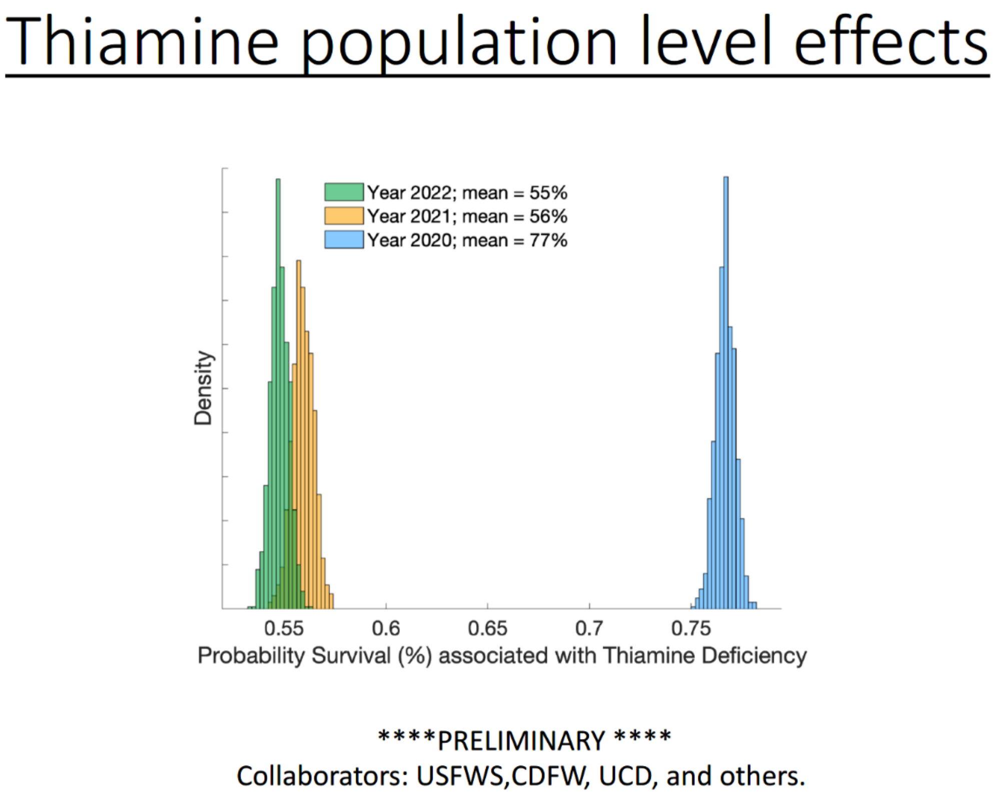

Figure 4. Slide from NMFS (2022b) showing values for thiamine-dependent survival for 2020, 2021 and 2022. Though it has been studied by NMFS-SWFSC since 2020, detailed methods and results from thiamine-deficiency studies have not been shared with the broader scientific community. Therefore, it is not clear if these estimates of thiamine-deficient survival are what would be incorporated into the Martin model (see Figure 2).

An October presentation (NMFS 2022a) depicted—for the first time—how thiamine-deficient survival might be incorporated into the Martin model (Figure 2). It is not currently known whether or how the SWFSC will incorporate thiamine-deficiency survival into the Martin model. However, if it is done as depicted in Figure 2 using the 2022 thiamine-dependent survival value of 55% (Figure 4), between 1.2 and 1.6 million fry should have arrived at RBDD (Table 1). Thus, thiamine-deficiency at best provides an incomplete explanation for poor production of juvenile winter-run Chinook resulting from implementation of the 2022 IOP.

VII. The Requested 2023 IOP Extension is predicated on scientific misunderstanding, not a scientific disagreement

30. I have closely tracked scientific information relevant to Sacramento River flow and temperature management since 2016. Discrepancies between studies and management actions

pursued by federal and state parties and others have sometimes been characterized as scientific disagreements. Though there are certainly scientific disagreements, the problem is more fundamental—the Martin model has been presented and utilized as a definitive tool for managing the Sacramento River temperatures and Shasta water storage. Many scientists and decision makers have accepted this designation, either overlooking or failing to recognize major flaws in this approach. For example, the State's expert, Dr. Herbold, repeatedly claims the Martin model accounts for both temperature and flow effects on ETF. Supplemental Declaration of Bruce Herbold in Support of Motion for Interim Injunctive Relief and Temporary Sta of Litigation (Suppl. Herbold Decl.) *CNRA* ECF No. 252-3 at 4:23-24, 7:9-10, 7:17-18, 8:22-23. In reality, the Martin model does not account for Sacramento River flow effects on either eggs or fry. The confusion is somewhat understandable—reliably predicting egg incubation survival (as the Martin model purports to do) would require accounting for the effect of river flows on spawning success and the effect of flow and temperatures on fry survival. However, the Martin model does not do so.

31. My prior declarations have detailed these flaws extensively. However, some of the issues are extremely technical and require a significant investment of time and effort to fully understand. Here I provide four relatively simple examples that identify "red flags" regarding the purported reliability of the Martin model. Put another way, if the Martin model were as robust and useful as claimed, these examples would not exist.

(1) TDM is the key output of the Martin model used to guide water temperature management. In planning and evaluating management decisions, TDM is routinely and persistently expressed as a precise point estimate (e.g., 23%) without any representation of confidence intervals. Confidence intervals are available (Figure 5) and reported in the original publication (Martin et al. 2016). It is standard, accepted scientific practice to report confidence intervals where uncertainty in the estimate is known to exist. It is my opinion that confidence intervals are not reported because the confidence intervals are very large (Figure 5)—to report those confidence intervals would undermine trust, perceived utility, and acceptance of Martin model results.

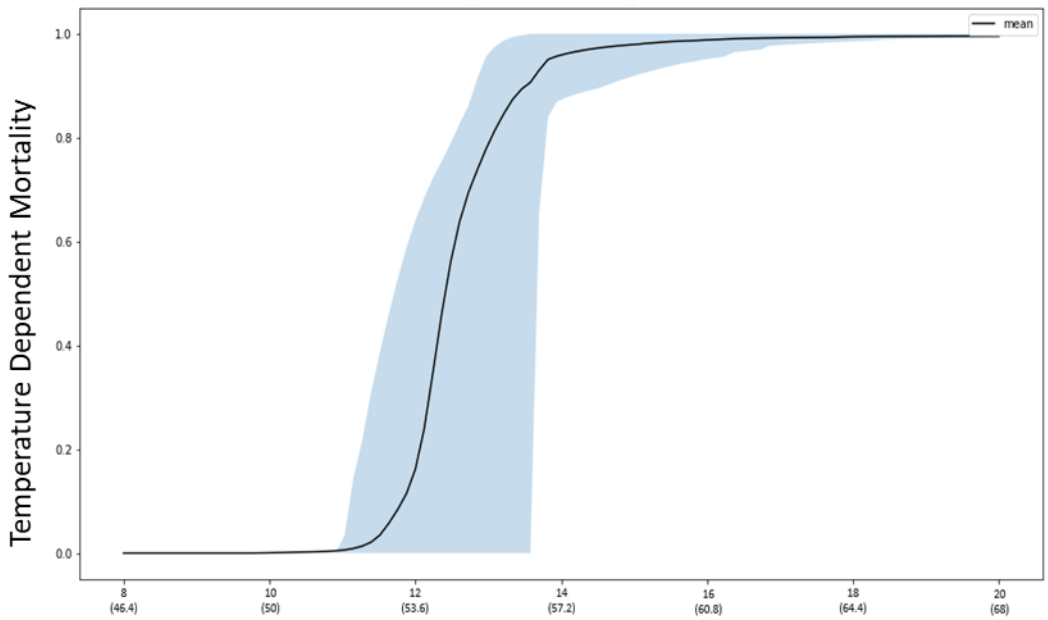

Figure 5. The relationship between water temperature (X-axis) and temperature dependent morality (TDM) as precited by the Martin model (Martin et al. 2016). The blue shaded region depicts the 95% confidence interval for predicted TDM at each water temperature. TDM confidence intervals for water temperatures targeted by the 2022 IOP range from 0% to nearly 100%.

(2) An essential and consequential assumption of the Martin model is that all mortality of eggs or juveniles not attributable to temperature-dependent egg incubation mortality is appropriately aggregated as "background survival" and assumed to be constant (~36%) across all years. As just one example, the assumption means that river flows and water temperatures have no effect on survival of fry as they migrate 67 miles from the spawning grounds to Red Bluff. To the best of my knowledge, no biologist has or would assert that this is a reasonable assumption. Independent experts have either recognized invariable survival of winter-run fry as a dubious, untested assumption (Gore et al. 2018) or they have asserted incorrectly that fry survival from the spawning grounds to Red Bluff is estimated by tracking tagged hatchery fish (Suppl. Herbold Decl. at 4:8-9).

(3) Because of the background survival assumption, ETF survival predicted by the Martin model cannot exceed 36%. That is, predicted ETF survival equals the background survival value when TDM and density dependent mortality are zero (see Figure 2). Yet, there are four instances (1997, 2010, 2011, and 2017) where observed ETF survival has exceeded 36%. This is a simple example, but it further illustrates a

significant, unacknowledged flaw with the Martin model's fixed background survival assumption.

(4) Fundamentally, science is the process of proposing hypotheses and then conducting studies to see if those hypotheses can be rejected due to inconsistency with collected data. However, efforts to conduct new studies that would allow hypotheses suggested by the Martin model to be tested have been rejected by federal and state agencies.

VIII. The Requested 2023 IOP Extension would not adequately support conservation of winter-run Chinook salmon

32. Biological results suggest the 2022 IOP did not provide the beneficial outcomes for winter-run Chinook salmon that were hypothesized earlier this year. As described previously, the focus on managing for the coldest possible water temperatures during egg incubation while inadequately considering how flows and temperatures might affect production of juvenile winter-run Chinook was a major flaw for the 2022 IOP. Another problem was the failure to consider or effectively implement non-temperature management actions that would complement or backstop operational strategies. For example, the 2022 IOP identifies the intent to support "winter-run Chinook survival and growth at [LSNFH] and other measures to limit risk to the population of winter-run Chinook salmon from a third year of low survival." *See* ECF No. 286-1 at 5:5-7. However, no actions other than temperature management were identified. To achieve better success in protecting winter-run Chinook salmon, any 2023 IOP Extension should specify what "other measures" will be taken, how they will benefit winter-run Chinook, and how these actions will compliment or backstop temperature and flow management strategies. Examples of operational and non-operational actions that should be included in any 2023 IOP Extension include the following:

A. Use new methods and/or modify existing methods to augment collection of adult pre-spawning winter-run Chinook salmon

(1) Background

33. The USFWS operates LSNFH, a conservation hatchery program supported in the NMFS recovery plan (NMFS 2014) and authorized under the Federal ESA (NMFS 2017). Adult winter-run Chinook salmon are trapped at Keswick Dam in order to supply broodstock for LSNFH. As a condition of its ESA coverage, LSNFH is required to rely on naturally produced winter-run Chinook for its broodstock (NMFS 2017). Using hatchery returns as broodstock contributes to domestication selection—the loss of traits that allow salmon to survive and reproduce successfully in the natural environment—and undermines the conservation value of the hatchery program. However, LSNFH has been unable to meet its natural-origin broodstock requirement since 2019, despite natural-origin winter-run Chinook adults being abundant in the Sacramento River. For example, nearly 3,000 natural-origin winter-run adults spawned in the Sacramento River in 2020 (CDFW 2022). Yet in 2020, LSNFH's winter-run broodstock (171 fish) was comprised of 65% hatchery-origin fish and just 35% natural origin (USFWS 2021). In 2022, the IOP agencies set a goal of collecting 680 adult winter-run Chinook for LSNFH and for other actions, but were unable to meet this goal even with expanded trapping operations at Keswick Dam. In addition, only 147 natural origin winter-run Chinook were collected in 2022 (42% of trapped winter-run), despite approximately 90% of in-river spawning winter-run Chinook being of natural origin (CDFW 2022).

34. In addition to LSNFH requiring more natural-origin winter-run Chinook for their conservation hatchery broodstock, augmented adult collections are also needed to support experimental reintroductions, field studies of egg-incubation survival. Augmented adult collections also provide a means to treat in-river spawning winter-run Chinook salmon for thiamine deficiency.

35. USFWS staff are not at fault for difficulties collecting adult winter-run—demands for collection of adult winter-run have grown/changed and natural-origin fish have become less vulnerable to capture at the Keswick Dam trap. This issue is raised here (as well as other issues

which follow) to call attention to winter-run conservation actions that are not presently being considered or effectively pursued by agencies requesting the 2023 IOP Extension.

(2) Action description

36. Deploy a temporary, removable trap (or traps) into the Sacramento River to capture pre-spawning winter-run Chinook adults. Designs for suitable traps that have proven to be effective and to cause minimal stress to adult Chinook salmon are readily available. The priority uses for winter-run Chinook captured at the trap would be as follows:

- Provide natural-origin fish to LSNFH such that no hatchery-origin returns are used as broodstock (consistent with NMFS 2017).
- Captured females not retained as hatchery broodstock, should be treated for thiamine deficiency before returning them to the Sacramento River. Such treatment occurred in 2022, but too few female winter-run Chinook salmon were captured at the Keswick Trap for the action to substantially benefit the population.
- If excess hatchery origin fish are available, retain some of them for use in experimental reintroductions (McCloud River, Battle Creek) and/or for in-river egg survival studies (*see* section VIII.C *infra*).

(3) Benefits to winter-run Chinook salmon

37. Allowing LSNFH to utilize 100% natural-origin broodstock would maximize the conservation value of the winter-run Chinook hatchery propagation program and would provide for consistency with ESA permitting requirements. Benefits from treating female winter-run Chinook salmon that will spawn in-river would yield substantial benefits to fry production even if relatively few females are captured and treated. For example, if thiamine-dependent survival is 56% (Figure 4) then treating 100 female salmon for thiamine-deficiency and releasing them back to the Sacramento River would produce as many as 180,000 additional winter-run Chinook fry. Using additional winter-run Chinook eggs to conduct in-river egg survival experiments would yield, for the first time, direct estimates of egg incubation survival which would help to evaluate 2023 operations as well as inform operations in subsequent years. As 2022 results further

demonstrate, it is simply not defensible to continue relying on standard monitoring and Martin model predictions which are based on that monitoring.

B. Alternative temperature and flow management strategies for winter-run Chinook salmon should be developed and evaluated

(1) Background

38. As described previously, Martin model predictions attribute mortality to temperature effects during egg incubation when those effect are more likely occurring because of flow effects on eggs and/or temperature/flow effects on fry after emergence.

(2) Action description

39. Alternative temperature and flow management strategies for 2023 might include targeting 56°F at the Clear Creek gauge while providing higher flow release from Keswick Dam. Alternatively, target 60°F at the Clear Creek gauge while providing higher flows until winter-run egg incubation is 50% complete, and thereafter manage to the coldest temperatures that can be sustained. This cold-water-later operational strategy has not previously been attempted on the Sacramento River, even though temperature sensitivity of incubating salmon eggs is known to be less in the first half of incubation, and greatest closer to hatching (e.g., Geist et al. 2006). Modeling that accounted for Shasta storage, water deliveries, Delta water quality requirements and other factors would be necessary to develop specific flow and temperature regimes. Whatever operations are ultimately selected for 2023, effects on egg survival and effects on fry survival must be evaluated separately and directly. Appropriate information is not provided by standard monitoring to reliably account for sources of mortality between eggs and juveniles at RBDD (*see* section VIII.C *infra*).

(3) Benefits to winter-run Chinook salmon

40. Just as 2022 operations did not yield the beneficial outcomes for winter-run Chinook that were hypothesized, there is uncertainty about results of alternative operations in 2023. Alternative operations such as those described above need to be considered because they are supported by available scientific and because the Martin model-based operation management has not proven to be effective.

C. Implement new field studies to better estimate egg incubation survival and survival of fry after emergence

(1) Background

41. Existing monitoring does not provide data that allows egg or fry survival to be measured directly. What has been called ETF survival is an index that relates the estimated number fry-equivalents reaching RBDD with an approximation of how many eggs may have been deposited. This index of fry production is useful for assessing general patterns. However, the Martin model takes the index value and applies unrealistic and untested assumptions in order to force an estimate of temperature-dependent egg mortality. This approach has always been problematic (Gore et al. 2018, Cavallo declarations), but winter-run results from WY 2022 operations have further proven the point. In order to make more effective management decisions—appropriately balance river flows, river temperatures, and water deliveries with other management actions—it is essential to begin monitoring egg survival and fry survival separately and directly.

(2) Action description

42. Robust and reliable methods for directly measuring in-river survival of incubating salmon eggs are readily available (Rubin 1995; Dumas and Marty 2006; Roni et al. 2015). The most appropriate methodology for the Sacramento River would be to place a known number of winter-run Chinook eggs (from action described in section VIII.A) in a small incubation chamber buried in an artificially created salmon nest (redd). After incubation is complete, the buried chamber is removed from the gravel and the number of surviving fry is counted directly. By placing multiple incubation chambers along a gradient of water temperatures and in different spawning habitats (i.e., with different depths or water velocities) egg survival for naturally spawning winter-run Chinook would be much more accurately estimated than is possible with existing monitoring or from the Martin model. It is important to note that these direct, in-river studies of egg survival and environmental factors influence egg survival were recommended in the September 2020, Sacramento River Science Partnership Science Plan (https://www.sacriverscience.org). Directly estimating egg survival would also greatly increase the information value of juvenile abundance estimates provided by existing

monitoring at RBDD. For example, if incubation chambers indicate good egg survival, but juvenile abundance remains low at RBDD, this would suggest excess mortality is occurring during the fry life stage. Again, these augmented data collection efforts are urgently needed because robust, independent estimates of egg incubation mortality and fry mortality cannot be reliably made from existing monitoring alone.

(3) Benefits to winter-run Chinook salmon

43. More effective management decisions demand more reliable information about the influence of river flows, river temperatures, water deliveries and other management actions on the survival of winter-run Chinook salmon. Beginning to directly monitor egg incubation success on the Sacramento River will provide for a more rapid and accurate assessment of how well management actions have performed. Equally important, this information will guide improved river management actions in subsequent years.

IX. A decision extending the IOP through 2023 should not be made until additional material information is made publicly available as to the effectiveness (or ineffectiveness) of the 2022 IOP and to inform whether further modifications are warranted

44. This declaration relies on information which was available as of October 21, 2022. Though it is my opinion that the IOP should not be extended through 2023, the updated information listed below should be made available in the near-term to inform and guide decisions about operations and other management actions appropriate to protect winter-run Chinook salmon in 2023.

- Winter-run juvenile production index (JPI) for 2022
- Winter-run spawning escapement estimate for 2022, including number of females and fecundity
- Methods and results for thiamine-deficient survival studies for 2020, 2021, and 2022
- Methods and results for modifications to the Martin model to include thiamine-deficient survival
- Estimates of ocean harvest impacts to winter-run Chinook salmon age 3 and age 4 in 2021 and 2022

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed this 31st day of October 2022, in Sacramento, California.

Bradley Cavallo

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EXHIBIT A

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Since joining Cramer Fish Sciences in 2006, Brad has led a growing team of scientists working to help resolve some of the Central Valley's most vexing fisheries management challenges. Brad is an experienced project and team leader, a diligent listener, and a resourceful problem-solver with more than 26 years of experience working on Central Valley and Delta fish issues. Brad has provided scientific leadership on a variety of multiagency and stakeholder involved investigations including the 2012 Steelhead Stipulation Study, the Collaborative Science and Adaptive Management Team, Oroville Facilities fisheries studies and environmental compliance, State Water Project ESA consultation, and the Delta Conveyance Project. Brad's Central Valley salmonid expertise is demonstrated by numerous related project reports, published papers and scientific presentations. Brad possesses expert knowledge of juvenile salmonids in the Delta-- how they are affected by hydrodynamic conditions, diversions, barriers, habitat modifications, and predators. Brad excels as a team leader, especially with complex and contentious projects. His in-depth knowledge of Delta salmonid issues and critical reasoning skills have contributed beneficially to many Delta and Central Valley fisheries-related projects. Brad's project experience emphasizes linking physical models (flows, temperatures, diversions) with biological monitoring data to explore the influence of water project operations and habitat quality on salmon and steelhead populations.

Brad is currently Vice-President of Cramer Fish Sciences and is a Past-President of the California-Nevada Chapter of the American Fisheries Society.

Employment History

Principal Scientist. Cramer Fish Sciences, Auburn, CA. 2010-present.

Associate Consultant, Fisheries Scientist. Cramer Fish Sciences, Auburn, CA. 2006-2009.

Senior Environmental Scientist, California Department of Water Resources, Sacramento, CA. 2003-2006.

Environmental Scientist. California Department of Water Resources, Sacramento, CA. 1999-2003.

Fisheries Biologist. California Department of Fish and Game, Stockton, CA. 1998-1999.

Scientific Aid, California Department of Fish and Game, Rancho Cordova, CA. 1997-1998.

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